

REMARKS

Applicant has amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicant has canceled previously considered claims 1-16 without prejudice or disclaimer, and have added new claims 17-30 to the application. Of these newly added claims, claim 17 is the sole newly added independent claim.

Claim 17 defines a method of manufacturing a semiconductor integrated circuit device, including, inter alia, providing a silicon wafer covered with an insulating film whose main surface is mainly formed of silicon oxide and cleaning the surface of the silicon wafer by a sheet-by-sheet manner using a processing solution containing hydrogen peroxide, hydricid fluoride salt and water; thereafter removing the insulating film to expose the surface of the silicon wafer; and subjecting the wafer to a heat treatment after removing the insulating film, to form a gate oxide film over the silicon wafer. Note, for example, Figs. 1-8, 10 and 11 of Applicant's specification, particularly together with the description on pages 12-18 of Applicant's specification.

Claims 18 and 19, each dependent on claim 17, respectively defines the hydricid fluoride salt as being ammonium fluoride and as being tetraalkyl ammonium fluoride. Claims 20 and 21, each dependent on claim 17, respectively recites that the processing solution includes HF and HF_2^- as etching seeds of the silicon oxide; and recites that the concentration of the hydricid

fluoride salt is in a range of about 0.1-3 mol/l. Claims 22 and 23, each dependent on claim 17, respectively recites that the processing solution further includes a surfactant; and recites cleaning the surface of the wafer during ultrasonic vibration of the processing solution. Claims 24 and 25, each dependent on claim 17, respectively recites that after the step of removing the insulating film, the heat treatment in step (d) is performed without exposing the silicon wafer to atmosphere; and recites a temperature at which the cleaning is performed. Claims 26 and 27, dependent respectively on claims 17 and 26, respectively recites a pH of the processing solution, and recites that the processing solution further includes a surfactant; and claim 28, dependent on claim 17, recites that in the heat treatment forming the gate oxide film, such heat treatment is performed in a mixed atmosphere of water and oxygen, at a temperature in a range of 800°-900°C. Claims 29 and 30, dependent respectively on claims 17 and 29, respectively recites that after removing the insulating film in step (c) the silicon wafer is dried prior to the heat treatment of step (d); and that after the drying the silicon wafer is immediately transferred to a chamber for the heat treatment of step (d).

In connection with the newly added dependent claims, attention is directed to, for example, pages 14-18 of Applicant's specification.

The objection to claim 2 as set forth in Item 1 on page 2 of the Office

Action mailed December 5, 2001, is noted. In view of present canceling of claim 2, this objection to claim 2 is moot.

The rejection of claims 6 and 15 under the second paragraph of 35 USC 112, set forth in Item 3 on page 2 of the Office Action mailed December 5, 2001, is noted. Claims 6 and 15 have been canceled without prejudice or disclaimer, and the remaining claims in the application do not utilize the expression "an ordinary temperature and a temperature nearly equal thereto". In this regard, note, for example, claim 25, reciting that the cleaning is performed at a temperature as low as 40°C. See the last paragraph on page 6 of Applicant's specification. In view of the claims presently before the Examiner, it is respectfully submitted that the indefiniteness rejection of claims 6 and 15 is moot.

Applicant respectfully submits that all of the claims now presented for consideration by the Examiner patentably distinguish over the teachings of the references as applied by the Examiner in rejecting the claims as formerly in the application, that is, the teachings of the U.S. patents to Ohmi, et al., U.S. Patent No. 5,990,060, to Okutani, No. 5,135,608, to Kinoshita, et al., No. 5,158,616, to Ohmi, et al., U.S. Patent No. 5,277,835 (hereinafter '835 patent), and to Yokoyama, et al., No. 5,858,863, under the provisions of 35 USC 103.

It is respectfully submitted that these references as applied by the Examiner would have neither taught nor would have suggested such a method of

manufacturing a semiconductor integrated circuit device as in the present claims, including, inter alia, wherein the surface of the semiconductor wafer, covered with an insulating film whose main surface is mainly formed of silicon oxide, is cleaned by a sheet-by-sheet manner with use of a processing solution containing hydrogen peroxide, hydricid fluoride salt and water; and, thereafter, removing the insulating film to expose the surface of the semiconductor wafer and then forming a gate oxide film over the silicon wafer by a heat treatment after the aforementioned removal of the insulating film.

That is, as set forth in claim 17, and as will be further discussed infra, it is respectfully submitted that these references do not disclose, nor would have suggested, wherein the surface of the semiconductor wafer having a surface mainly formed of silicon oxide is cleaned using the recited processing solution containing hydrogen peroxide, hydricid fluoride salt and water, and thereafter steps are performed removing the insulating film and then forming a gate oxide film over the silicon wafer.

In addition, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested the other aspects of the present invention as in the remaining, dependent claims, wherein the cleaning step is performed prior to forming the gate oxide film, and further wherein the hydricid fluoride salt is ammonium fluoride or tetraalkyl ammonium fluoride (note claims 18 and 19, respectively); or wherein the processing solution

includes HF and HF_2^- as etching seeds of silicon oxide (note claim 20); or amount of hydricid fluoride salt in the processing solution as in claim 21; and/or wherein the solution further includes a surfactant (note claims 22 and 27), or pH of the processing solution in the range of 6-11 (note claim 26); or wherein a step of cleaning during ultrasonic vibration of the processing solution is performed (see claim 23); and/or temperature of the cleaning as in claim 25; and/or temperature and atmosphere for the heat treatment forming the gate oxide film, as in claim 28; and/or other aspects of the present invention including the drying step (note claim 29); and/or wherein the heat treatment for forming the gate oxide film is performed in a chamber to which the wafer is transferred immediately after the drying (see claim 30), or wherein the heat treatment is performed without exposing the silicon wafer to atmosphere (see claim 24).

The present invention is directed to a technique of manufacturing a semiconductor integrated circuit device, particularly advantageously applied to a cleaning processing for a silicon wafer.

In manufacturing a large scale integrated circuit using a wafer made of mono-crystalline silicon, a so-called RCA wafer cleaning technique has been used, as described in the paragraph bridging pages 1 and 2 of Applicant's specification.

However, there is a desire to improve the RCA cleaning technique, and various attempts to improvement thereof have been made, as described on pages

2-4 of Applicant's specification. However, these proposed techniques have been insufficient particularly for the process of forming a gate of a MOSFET, which requires a thin gate oxide film of high quality. See the second full paragraph on page 4 of Applicant's specification.

Against this background, Applicant provides a technique having especially advantageous effects for cleaning a semiconductor wafer, in processing for forming a gate oxide film of a semiconductor integrated circuit device. Applicant has found that by utilizing a processing solution containing hydrogen peroxide, hydricid fluoride salt and water, for cleaning the surface of the silicon wafer, with the wafer being cleaned by a sheet-by-sheet manner; and with the insulating film thereafter being removed to expose the surface of the silicon wafer and the silicon wafer then being subjected to a heat treatment to form the gate oxide film, the cleaning can be performed at relatively low temperatures and wherein the silicon oxide film is cleaned and etched without etching the silicon substrate, so that contamination of the substrate can be avoided. Moreover, through use of the processing solution of the present invention in processing steps leading up to forming the gate oxide film, the cleaning can be accomplished in a short time and at a low temperature, without deteriorating flatness of the wafer surface. Note, for example, the first full paragraph on page 6 of Applicant's specification.

Ohmi, et al. discloses a cleaning method and a cleaning device which can remove foreign materials deposited on a substrate after removal of photoresist by plasma processing. See column 1, lines 6-10. This patent discloses that foreign materials can be removed under room temperature, by using a cleaning liquid which is a basic and water-soluble fluoride and an oxidizing agent, mixed in pure water. Note column 2, lines 20-29. See also column 2, lines 37-39 and 48-51; column 3, lines 42-47; and column 4, lines 45-50. This patent further discloses that by irradiating ultrasonic waves to the cleaning liquid or pure water, it is possible to improve the cleaning effect. Note the paragraph bridging columns 3 and 4 of this patent. This patent further discloses that the cleaning liquid can be applied not only to removal of photoresist, but also to removal of various types of high polymer organic coating films such as paint or adhesive, films of machine oil, as well as removal of surface surfactant or dye or the like. See column 8, lines 24-34.

It is emphasized that Ohmi, et al. is primarily concerned with a cleaning liquid and cleaning method removing organic materials, particularly removal of photoresist. It is respectfully submitted that this patent is primarily concerned with removal of photoresist in connection with ion injection or reactive ion etching processes. It is respectfully submitted that this patent does not disclose, nor would have suggested, the presently claimed process, including performance

of the recited cleaning using the specified processing prior to and with forming the gate oxide, and advantages achieved thereby as discussed in the foregoing.

In connection with the cleaning prior to forming the gate oxide by heat treatment, comments by the Examiner in the paragraph bridging pages 4 and 5 of the Office Action mailed December 5, 2001, in Item 7 of this Office Action, are noted. It is respectfully submitted that even interpreting the teachings of Okutani and Yokoyama, et al. as applied by the Examiner (and discussed further infra), these references would have neither taught nor would have suggested the cleaning of the surface of the wafer using the recited processing solution as in claim 17, and thereafter removing the insulating film whose main surface is mainly formed of silicon oxide and thereafter performing the heat treatment to form the gate oxide film, as in the present claims.

That is, it is respectfully submitted that the secondary references as applied by the Examiner would not have rectified the deficiencies of Ohmi, et al., such that the presently claimed invention as a whole would have been obvious to one of ordinary skill in the art. Kinoshita, et al. discloses substrate cleaning apparatus used in the manufacture of a semiconductor device, particularly apparatus for cleaning substrates (wafers) arranged vertically. The cleaning apparatus is described most generally at column 2, lines 27-38 of this patent. This patent discloses that the substrates may be vertically supported in the treatment chamber with an ultrasound oscillation source provided at least on

a major surface side of the substrate. See column 2, lines 50-56. Note also column 5, lines 13-25 of Kinoshita, et al., describing, as the cleaning solution, for example, a blend solution of hydrogen peroxide with sulfuric acid or hydrochloric acid, hydrofluoric acid, and so on selected for acid cleaning and a blend solution of ammonia and hydrogen peroxide selected for alkali cleaning.

Even assuming, arguendo, that the teachings of Kinoshita, et al. were properly combinable with the teachings of Ohmi, et al., such combined teachings would have neither disclosed nor would have suggested the presently claimed subject matter, including the cleaning, and thereafter removal of the insulating film and thereafter the heat treatment to form a gate oxide film, as in the present invention, and advantages achieved thereby.

The '835 patent discloses a surface treatment agent for use in fine surface treatment which is very effective for wet etching of silicon oxide films in the manufacturing process of semiconductor devices, as well as for cleaning of fine-treated semiconductor devices. See column 1, lines 12-18. This patent discloses reduction in NH_4F concentration of buffered hydrogen fluoride to less than 15%, and preparing HF concentration to be in the range of less 8%, thus maintaining etching speed of SiO_2 film up to 1500Å/min and resist protectability. Note the paragraph bridging columns 2 and 3 of this patent; see also column 3, lines 17-56 for various surface treatment agents in the '835 patent. See also column 2, lines 55-61 of this patent.

Even assuming, arguendo, that the teachings of the '835 patent were properly combinable with the teachings of Ohmi, et al. and Kinoshita, et al., such combined teachings would have neither disclosed nor would have suggested the cleaning prior to removal of the insulating film and thereafter subjecting the wafer to heat treatment to form the gate oxide film, as in the present invention. It is respectfully submitted that these applied references do not mention gate oxide formation, and that these references would not have disclosed nor would have suggested the cleaning prior to the gate oxide formation as in the present invention.

Yokoyama, et al. discloses a fabrication method capable of fabricating various kinds of semiconductor devices for a short period of time, the fabricating system being described most generally at column 6, lines 14-30. See also column 11, lines 57-62 of this patent.

Okutani discloses technology that can be effectively adapted to thin-film forming and etching technology in processing wafers used for semiconductor devices. This patent discloses dry and wet processing steps of the wafer, and carrying the wafer between the dry and wet processing. The dry and wet processing steps, and transport of the wafer therebetween, are continuously carried out in a predetermined atmosphere while shutting off the open air. Note, for example, column 2, lines 26-34 of Okutani. Note also column 2, lines 42-53.

It is respectfully submitted that Yokoyama, et al. is concerned with a fabricating system for transport and processing of wafers; Okutani has similar concerns. It is respectfully submitted that these references, either alone or in combination with the teachings of the other references as applied by the Examiner, would have neither taught nor would have suggested the presently claimed process, including cleaning utilizing the recited processing solution and thereafter removal of the insulating film to expose the surface of the silicon wafer and then formation of the gate oxide film.

Furthermore, taking the teachings of all applied references as a whole, as applied by the Examiner, it is respectfully submitted that the teachings of these references would have neither taught nor would have suggested the aspects of the present invention as in the present claims, including the cleaning treatment using the recited processing solution, with the insulating film thereafter being removed and still further thereafter the heat treatment is performed to form the gate oxide film, and also including the other aspects of the present invention as in the dependent claims and discussed previously.


In view of the foregoing comments and amendments to the claims, reconsideration and allowance of all claims remaining in the application are respectfully requested.

To the extent necessary, Applicants petition for an extension of time under 37 CFR 1.136. Please charge any shortage in fees due in connection with the

filing of this paper, including extension of time fees, to the Deposit Account No. 01-2135 (Case No. 843.37558VX2) and please credit any excess fees to such Deposit Account.

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP


William I. Solomon
Registration No. 28,565

Tel.: 703-312-6600
WIS/slk